

Noncardiac Surgery in Long-Term Implantable Left Ventricular Assist-Device Recipients

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Objective

The authors describe their experience with left ventricular assist-device (LVAD) recipients undergoing noncardiac surgery and delineate surgical, anesthetic, and logistic factors important in the successful intraoperative management of these patients.

Summary Background Data

Left ventricular assist-devices have become part of the armamentarium in the treatment of end-stage heart failure. As the numbers of patients chronically supported with long-term implantable devices grows, general surgical problems that are commonly seen in other hospitalized patients are becoming manifest. Of particular interest is the intraoperative management of patients undergoing elective noncardiac surgical procedures.

Methods

The anesthesia records and clinical charts were reviewed for eight ventricular assist-device recipients undergoing general surgical procedures between August 1, 1990 and August 31, 1994.

Results

A total of 12 procedures were performed in 6 men and 2 women averaging 52.7 years of age. Mean time elapsed from device implantation to operation was 68 ± 35 days. Conventional inhalational and intravenous anesthetic techniques were well tolerated in these patients undergoing diverse surgical procedures. No perioperative mortality was observed. Five of eight patients went on to successful cardiac transplantation.

Conclusions

Hemodynamic recovery after LVAD insertion has defined a new group of patients who develop noncardiac surgical problems often seen in other critically ill patients. Recognition of the unique potential problems that the LVAD recipient may encounter in the perioperative period—in particular patient positioning, device limitations, and fluid and inotropic management—will ensure an optimal surgical outcome for LVAD recipients undergoing noncardiac surgery.

Table 1. CHARACTERISTICS OF LVAD RECIPIENTS UNDERGOING NON-CARDIAC SURGERY

Patient	Age, Sex	Etiology of Cardiomyopathy	Diagnosis	Total Implant Time (days)
1	63, M	Idiopathic	Respiratory insufficiency Right lower lobe empyema Sternal wound infection LVAD pocket infection	197
2	66, M	Idiopathic	Plication of bleeding gastric ulcer	98
3	51, M	Idiopathic	Renal mass Empyema	179
4	59, M	Ischemic	Poor venous access	225
5	55, M	Ischemic	Sternal wound infection	80
6	20, F	Idiopathic	Respiratory failure	23
7	51, F	Ischemic	Tooth abscess	84
8	57, M	Ischemic	Sacral decubitis ulcer	154

LVAD = left ventricular assist device.

Left ventricular assist devices (LVAD) have become part of the armamentarium in the treatment of end-stage heart failure. As the numbers of patients chronically supported with long-term implantable devices grows, general surgical problems that are commonly seen in other hospitalized patients are becoming manifest. Of particular interest is the intraoperative management of these patients while they undergo elective, noncardiac surgical procedures. The objective of this study is to describe our experience with LVAD recipients undergoing noncardiac surgery and delineate surgical, anesthetic, and logistic factors important in the successful intraoperative management of these patients.

METHODS

Between August 1, 1990 and August 31, 1994, 28 patients underwent Thermo Cardiosystems Inc. 1000IP or 1205 VE LVAD (TCI LVAD) placement as a bridge to transplantation at Columbia Presbyterian Medical Center. Eight of these patients underwent noncardiac surgical procedures while supported with an LVAD. The anesthesia records and clinical charts of these patients were reviewed.

RESULTS

Six men and two women underwent a total of 12 surgical procedures (Table 1). Mean age of the patients was

52.7 ± 14.3 years, with a range of 20 to 66 years. Etiologies of end-stage heart failure included ischemic cardiomyopathy (4) and idiopathic cardiomyopathy (4). Surgical procedures included wound debridement and flap coverage (4), thoracotomy (2), tracheostomy (2), laparotomy (2), tooth extraction (1), and central venous access (1). Time elapsed between LVAD implantation and surgical procedure averaged 68 ± 35 days and ranged from 21 to 138 days. Nine of the operative procedures were performed under general endotracheal anesthesia, two were performed under local anesthesia, and one was performed under monitored anesthesia care. All patients received prophylactic antibiotics before skin incision. In addition, those patients deemed at high risk for fungal infection (recent or current use of broad spectrum antibiotics or multiple indwelling lines) received antifungal prophylaxis. Anticoagulation is not required for patients supported with the TCI LVAD¹; therefore, none of the patients received heparin or other anticoagulants perioperatively.

Intraoperative Requirements

All patients undergoing general endotracheal anesthesia had an uneventful induction. General intraoperative monitoring and fluid requirements are depicted in Table 2. A variety of intravenous and inhalational techniques were employed and well tolerated. Two patients required exogenous blood products during three procedures. Patient 1 required 1 unit of packed red blood cells for bleeding during sternal debridement and pectoralis muscle-flap coverage for a sternal wound infection. This same patient had undergone debridement of an infected LVAD pocket 4 days earlier and required packed red

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Table 2. INTRAOPERATIVE MONITORING, FLUID, INOTROPIC, AND PRESSOR REQUIREMENTS FOR LVAD RECIPIENTS UNDERGOING NONCARDIAC SURGERY

Case	Monitoring	Fluid Requirements			Inotropic Support	Vasopressor Support
		Blood Products	Crystalloid (mL)	Colloid (mL)		
1	Arterial line	None	250	None	—	—
2	Arterial line/CVL*	None	1300	None	Dobutamine	Neosynephrine
3	Arterial line	1 unit pRBC†	2000	None	—	—
4	Arterial line/CVL	2 units pRBC 6 units platelets 5 units ffp§	3000	None	—	—
5	Swan-Ganz catheter arterial line	5 units pRBC	2800	None	—	Intermittent neosynephrine
6	Swan-Ganz catheter/arterial line	4 units cell saver	4200	1500	—	—
7	Arterial line/CVL	None	2800	500	—	—
8	Peripheral venous access	None	150	None	—	—
9	Arterial line	None	1200	None	—	Ephedrine
10	Arterial line	None	250	None	—	—
11	Peripheral venous access	None	400	None	—	—
12	Arterial line	None	N/A¶	None	—	—

LVAD = left ventricular assist device.

* Central venous line.

† Packed red blood cells.

§ Fresh frozen plasma.

¶ Not available.

blood cells, fresh frozen plasma, and platelets for treatment of sepsis-induced coagulopathy. Patient 2 developed an upper gastrointestinal bleed 44 days after LVAD implantation. Because of persistent bleeding, he was taken to the operating room, where an actively bleeding gastric ulcer was found and plicated. During the operation, he received 5 units of packed red blood cells.

Patient 1 required inotropic and vasopressor support during a left pleural decortication for an empyema 57 days after LVAD implantation. Other than intermittent alpha-agonist support, none of the other patients required inotropic or vasopressor maintenance.

Two patients underwent invasive monitoring with thermodilution pulmonary artery catheters; the procedures were a nephrectomy for localized renal cell carcinoma and plication of bleeding gastric ulcer. In both cases, pulmonary artery diastolic pressures < 11 mm Hg were associated with hypotension and the need for fluids.

Complications

Anesthetic method and complications are summarized in Table 3. In four cases, the surgical procedure required the patient to be placed in the lateral decubitus position. In all four cases, this positioning resulted in decreased cardiac output as determined by LVAD flow.

The first time this complication arose, the patient was treated with dobutamine (Eli Lilly & Co., Indianapolis, IN), which resulted in worsening hypotension, requiring the institution of vasopressor support. The patient's hemodynamic status subsequently improved with fluid therapy. In three subsequent cases requiring lateral decubitus positioning, patients were hydrated before induction, resulting in stable hemodynamic intraoperative course.

One patient who underwent exploratory laparotomy for upper gastrointestinal bleeding was hypotensive during the case and required 5 units of packed red blood cells to improve hemodynamic status. A second patient demonstrated significant intraoperative bleeding secondary to a preoperative coagulopathy and required multiple blood products to reduce postoperative hemorrhage.

One patient became dyspneic immediately after uncomplicated sternal debridement, probably because of overmedication, and required temporary endotracheal intubation.

Additional complications noted throughout our experience included abrupt loss of power in the LVAD because of battery exhaustion and electrocautery-induced radiofrequency interference with the LVAD sensor when the LVAD performance was set in the "auto" mode.

Table 3. SURGICAL TREATMENT, TYPE OF ANESTHESIA AND PERIOPERATIVE COMPLICATIONS FOR LVAD RECIPIENTS UNDERGOING NON-CARDIAC SURGICAL PROCEDURES

Case	Surgical Procedure	Interval After Implantation (days)	Type of Anesthesia	Complications
1	Tracheostomy	76	General	None
2	Left pleural decortication	57	General	Hypotensive with positional change
3	Sternal debridement and pectoralis scler flap	52	General	None
4	LVAD pocket debridement and rectus abdominis muscle flap	48	General	Bleeding
5	Plication of bleeding gastric ulcer	44	General	Hypotension
6	Nephrectomy	134	General	Hypotensive with positional change
7	Right lower lobectomy	67	General	Hypotensive with positional change
8	Groshang catheter insertion	62	Local	None
9	Sternal debridement	71	General	Reintubation for dyspnea
10	Tracheostomy	21	General	None
11	Multiple tooth extraction	46	MAC	None
12	Debridement sacral decubitus ulcer and local flap	138	Local	Hypotensive with positional change

LVAD = left ventricular assist device, MAC = monitored anesthesia care.

No early postoperative morbidity or mortality occurred. Five of the eight patients (62.5%) went on to cardiac transplantation, two patients succumbed to sepsis unrelated to the surgical procedure, and one patient died after driveline rupture.

DISCUSSION

Left ventricular assist devices have increasingly become an accepted therapy for heart disease in the setting of postcardiotomy failure,^{2,3} acute myocardial infarction⁴⁻⁶ and as a bridge to transplantation^{1,7-9} in patients with end-stage cardiac failure. Moreover, it is plausible that long-term implantable devices will serve as alternative treatment for end-stage heart failure.¹⁰ Hemodynamic recovery after LVAD insertion has defined a new group of patients who develop noncardiac surgical problems often seen in other critically ill patients. In addition to routine perioperative care, special considerations are necessary in LVAD recipients who require surgical therapy.

First, TCI LVAD function is extremely dependent on preload. The dependence of LVAD outflow on preload makes patient positioning a significant determinant in LVAD support. Having experienced these changes with one patient, the following three cases requiring placement of the patient in the lateral decubitus position were evaluated after positioning and before induction. The patients were monitored for 10 minutes to assess the

effects on blood pressure and LVAD flow. In all instances, LVAD flow and blood pressure decreased. Patients were intravenously hydrated until these positional effects disappeared. Following this protocol, the intraoperative course was uncomplicated, and none of the patients required significant vasopressor support or blood product transfusion to maintain blood pressure.

Second, the TCI LVAD has a limited battery capacity. The time of patient transport to the operating room and preparation for surgery can exceed the device's 30-minute battery capacity. Limiting the period of time the device is disconnected from an AC power source will avoid the complication of power failure. It is imperative that the operating team be cognizant of this limitation. An additional logistic factor involves the use of electrocautery which can interfere with proper LVAD function when the device is in the "auto" mode. This can be avoided by placing the device in the fixed-rate mode.

Third, conventional inhalational and intravenous anesthetic techniques were well tolerated in these patients. The fluid, inotropic, and vasopressor requirements do not appear to be significantly different than those required in other patients undergoing similar procedures. Although invasive hemodynamic monitoring was occasionally required, the LVAD provides a continuous measure of cardiac output, thereby facilitating intraoperative volume management. Because the TCI LVAD employs textured biomaterials and porcine valves, the use of heparin, protamine, and activated clotting time monitoring

intraoperatively is not required. This reduces the chance of bleeding and autologous blood transfusion, a major concern for patients awaiting cardiac transplantation.

The LVAD adds a new dimension to the perioperative management of surgical patients. In addition to the routine hemodynamic and respiratory monitoring inherent in surgery, the surgical and anesthesia teams need to be cognizant of the potential problems that may arise as a result of the presence of a mechanical ventricular assist device. To this effect, an individual from the operating team (surgeon, anesthesiologist, or nurse) familiar with the device should be present at all times in the operating room.

Recognition of the unique potential problems that the LVAD recipient may encounter in the perioperative period—in particular, patient positioning, device limitations, and fluid and inotropic management—will ensure an optimal surgical outcome for LVAD recipients undergoing noncardiac surgery.

Author's Note

Since the submission of the manuscript, four additional LVAD recipients have undergone noncardiac surgical procedures. The operations included open cholecystectomy for acute cholecystitis, lobectomy for empyema, multiple tooth extraction, and debridement and flap reconstruction of decubitus sacral ulcer. All four patients underwent uneventful anesthesia induction following the principles outlined above. All patients had smooth intra- and postoperative courses; one patient

underwent transplantation while the other three patients remain well, awaiting transplantation.

References

1. McGee MG, Parnis SM, Nakatani T, et al. Extended clinical support with an implantable left ventricular assist device. *Trans Am Soc Artif Intern Organs* 1989; 35:614–616.
2. Curtis JJ. Centrifugal mechanical assist device for postcardiotomy ventricular failure. *Semin Thorac Cardiovasc Surg* 1994; 6:136–139.
3. Pennington DG, Merjavy JP, Swartz MT, et al. The importance of biventricular failure in patients with postoperative cardiogenic shock. *Ann Thorac Surg* 1985; 39:16–26.
4. Smalling RW, Sweeney M, Lachterman B, et al. transvalvular Left Ventricular Assistance in Cardiogenic Shock Secondary to Acute Myocardial Infarction. *J Am Coll Cardiol* 1994; 23:637–644.
5. Moritz A, Wolner E. Circulatory support with shock due to acute myocardial infarction. *Ann Thorac Surg* 1993; 55:238–244.
6. Deeb GM, Bolling F, Nicklas J, et al. Clinical experience with the nimbus pump. *ASAIO Trans* 1990; 36:M632–M636.
7. McBride LR. Bridging to cardiac transplantation with external ventricular assist devices. *Semin Thorac Cardiovasc Surg* 1994; 6: 169–173.
8. Frazier OH, Rose EA, Macmanus Q, et al. Multicenter clinical evaluation of the HeartMate 1000IP left ventricular assist device. *Ann Thorac Surg* 1992; 53:1080–1090.
9. Pennington DG, McBride LR, Peigh PS, et al. Eight years' experience with bridging to cardiac transplantation. *J Thorac Cardiovasc Surg* 1994; 107:472–481.
10. Frazier OH. The development of an implantable, portable, electrically powered left ventricular assist device. *Semin Thorac Cardiovasc Surg* 1994; 6:181–187.